Chapter 5

Cyclical and Irregular Analysis of Time Series

This chapter concludes the direct discussion of time series by presenting an example of actual data carried through the complete analysis of trend, seasonal, cyclical, and irregular components. Our choice for illustration is the highly cyclical capital investment industry of industrial wheel tractors, introduced in Chapter 3. You recall that industrial wheel tractors are primarily rubber-tired, two-wheel drive vehicles with large rear powered wheels and smaller front wheels. Their chief use is in excavation and construction, where the tractor is a power unit and transport vehicle for a combination of hydraulic front loader and hydraulic rear backhoe. Secondary uses include highway mowing, landscape preparation, and grounds maintenance.

5.1 Identifying Cyclical and Irregular Components

To provide a quick summary of the entire time-series analysis process, the four panels in Figure 5.1 show in condensed fashion the four different stages of the industrial wheel tractor data. Original, unadjusted sales are provided in Table 5.1 for reference throughout this chapter.

Panel A of Figure 5.1 shows original sales with trend, seasonal, cyclical, and irregular components. Recall that the four components of time series are identified by the nature of their change: seasonal patterns recur within a year; trend patterns are long, slow changes in the characteristic (sales) being monitored; and irregular fluctuations are identified by sporadic individual deviations from the smooth pattern of trend and cycle. Panel B illustrates seasonally adjusted sales where seasonal influences have been removed. Notice the strong cyclical movements, represented by major peaks and troughs, and the significant irregular component indicated by the erratic smaller fluctuations. Panel C shows smoothed seasonally adjusted sales from which the irregular movements have been removed by a smoothing process, described in the next section of this chapter. Finally, Panel D shows the cyclical ratios-to-trend, where the trend has been removed by fitting a second-degree polynomial curve through the original data.

The cyclical series in Panel D is of particular interest to the forecaster since he needs to determine as accurately as possible the current stage of the business cycle. This determination requires economic analysis of influences in the total economy and in the sector, industry, and particular company situation.

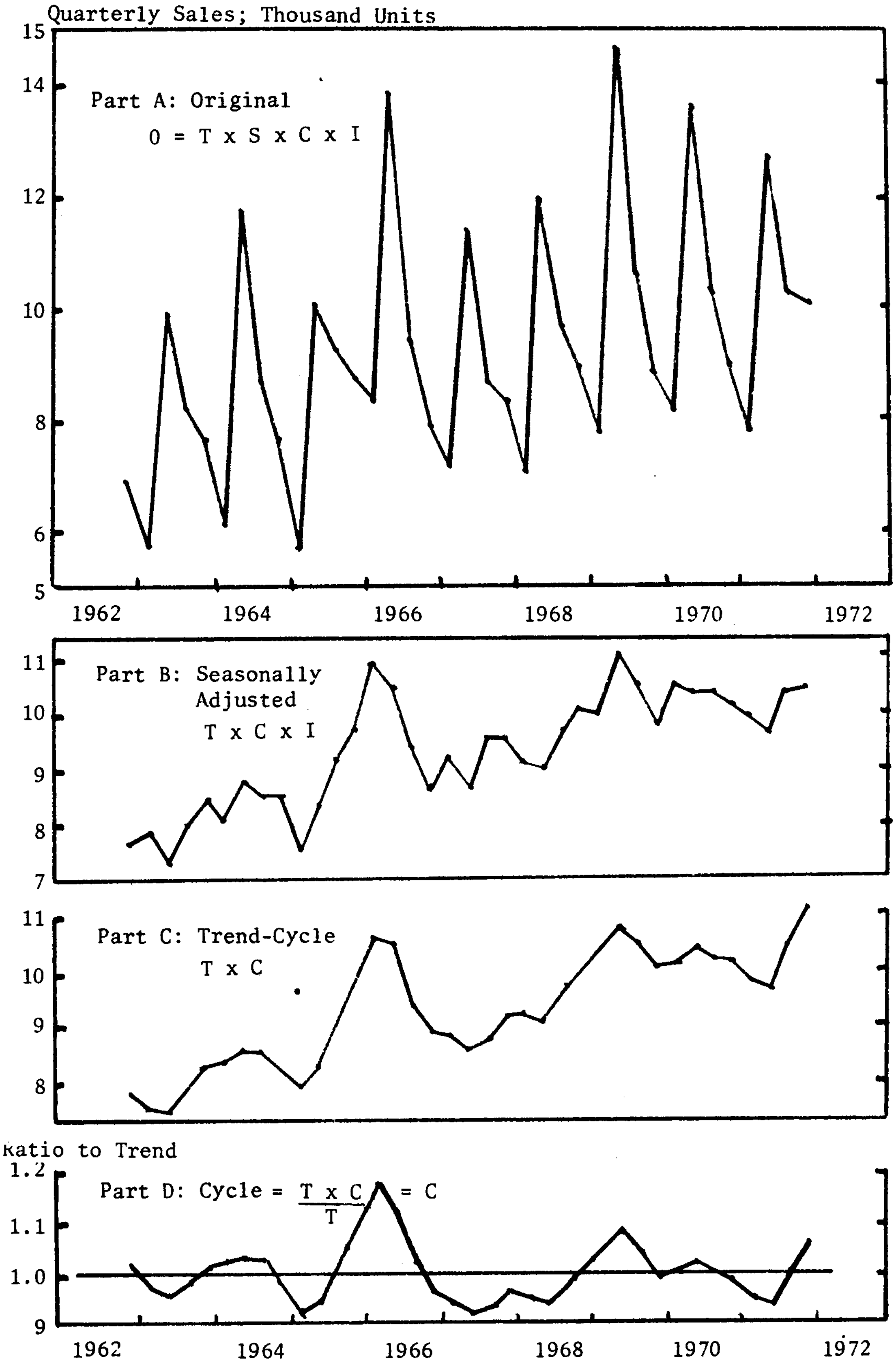
Recall that cyclical influences are only a part of the forecast for tractor retail sales. Other main elements in the forecast may consist of an extrapolated trend and a predicted seasonal pattern. Most sales forecasts contain no outlook for minor irregular influences. However, forecasts certainly must reflect the expectation of currently visible, significant, and unusual events, such as supply shortages caused by in-house fires, expected labor disputes, competitors' actions, transportation strikes, imposition of price controls, war, and so forth, which are relevant to the company or industry at hand. Indeed, the forecaster may well get bogged down in defining whether events qualify as being causes for irregular movement and to what extent their influences may be felt through future sales. There is no easy answer to this quagmire-type of dilemma, and it is at this point that forecasting sometimes becomes more of an art than a science.

For contrast, consider this second example. Figure 5.2 has the same basic panel arrangement as Figure 5.1, only this time for grocery sales of Safeway Stores Incorporated. This series has a relatively smooth trend, a stable seasonal pattern, almost no cycle, and small irregular effects, each of which may be perceived by examining Panels A, B, C, and D of Figure 5.2 in comparison with those of Figure 5.1. For Safeway sales, then, the stable trend and seasonal patterns, plus the absence of appreciable business cycle effects, enable the forecaster to direct his attention directly to causes of the possible future cyclical and irregular influences.

5.2 Calculating Cyclical and Irregular Components

The cyclical and irregular component (C x I) fluctuations in time-series data are residuals left after removing the secular trend (Chapter 3) and seasonal pattern (Chapter 4). Trend and seasonal methods are based on

Figure 5.1
Industrial Wheel Tractors; United States Industry Quarterly Sales



Source: Table 5.6

Table 5.1

Industrial Wheel Tractor Quarterly Unit Retail Sales

Input to Seasonal Adjustment X-11 Q Program

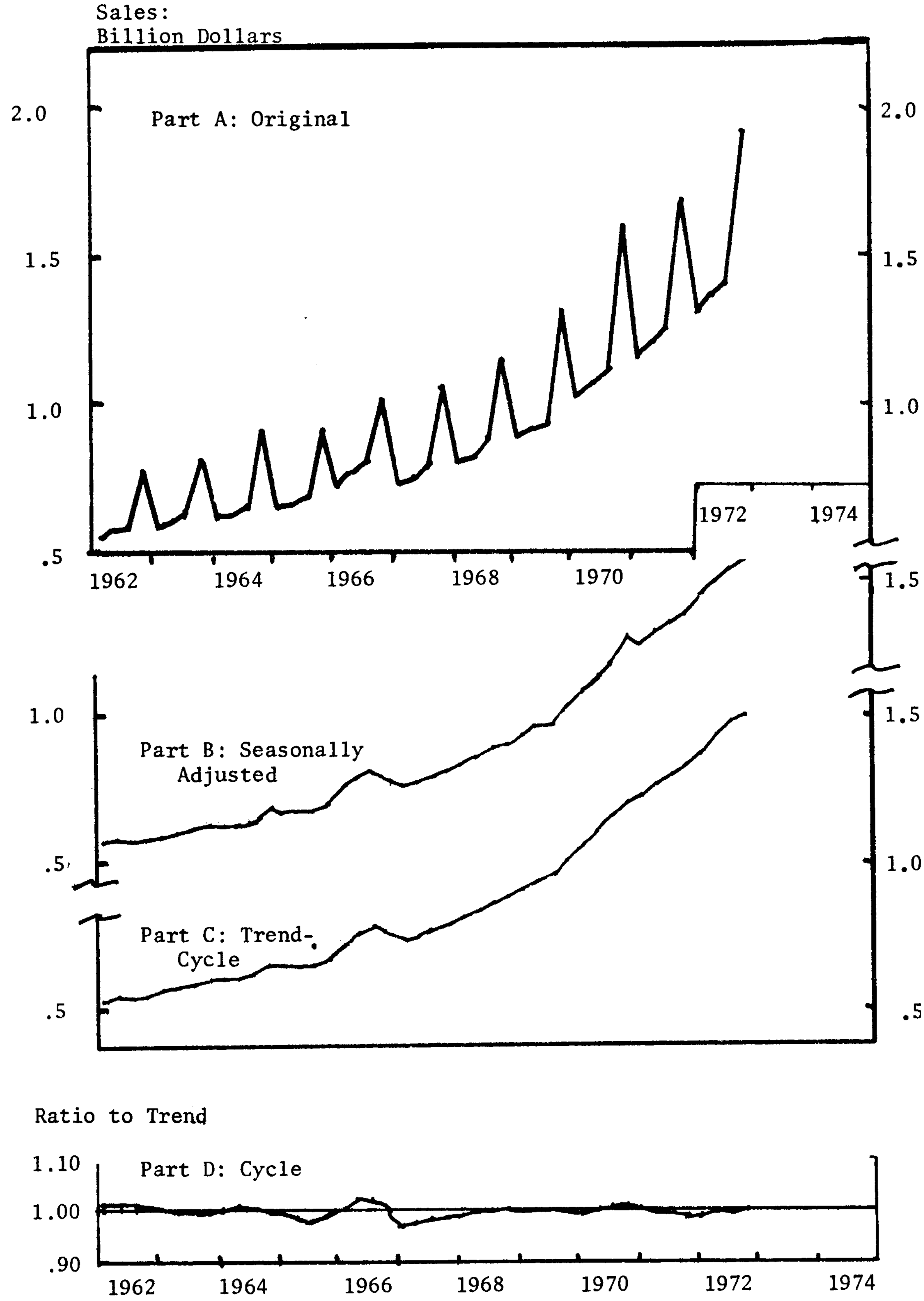
B1. ORIGINAL SERIES   2ND WH TR UNITS—FIEI DATA   PAGE 1, SERIES INDTRU

YEAR	1ST QUAR	2ND QUAR	3RD QUAR	4TH QUAR	TOTAL
1962				6997.	6997.
1963	5761.	9795.	8281.	7736.	31573.
1964	6160.	11824.	8806.	7753.	34543.
1965	5742.	11225.	9443.	8869.	35279.
1966	8452.	14019.	9580.	7874.	39925.
1967	7194.	11476.	8744.	8556.	35970.
1968	7078.	11982.	9318.	9011.	37389.
1969	7858.	14667.	10467.	8730.	41722.
1970	8166.	13645.	10307.	8969.	41087.
1971	7753.	12714.	10322.	10158.	40947.
1972	9195.	14866.	12235.	11655.	47951.
AVG	7326.	12621.	9750.	8755.	

TABLE TOTAL 393383   MEAN 9595.   STD. DEVIATION 2293.

Source: Farm Industrial Equipment Institute

Figure 5.2
Safeway Stores Incorporated Quarterly Retail Sales in Current Dollars



Source: Safeway Stores Incorporated

statistical characteristics of the economic concepts of trend and season. These economic concepts are explicitly identified in statistical methodology and usually can be measured with reasonable satisfaction. A chief exception relates to the problem of determining the current trend position when recent observations have strong cyclical fluctuations. It may be difficult, even impossible, to identify the shape of the current trend until the existing business cycle has been completely defined as to its phase, and this task sometimes requires several years of additional data.

Prefaced by these qualifications, we now present computations for the statistical values of the four components of time-series analysis for the industrial wheel tractor industry.

To take advantage of the extensive analysis done in the X-11 Q Census Method II Seasonal Adjustment Program the following sequence is used:

1. Calculate the seasonal factors, using the changing seasonal method of the X-11 Q Program, from Table D10 (Table 5.2) of the computer printout, entitled, "Final Seasonal Factors, 3x5 Moving Average."[1] Use these factors as the "S" in Step A presented subsequently.
2. Smooth the seasonally adjusted series to obtain the trend-cycle series, identified in the X-11 Q Program as Table D12 (Table 5.3) of the printout, "Final Trend-Cycle, 5-Term Henderson Curve."[2] See Step B. The smoothing conceptually removes the irregular component.
3. Calculate the trend by fitting a smooth long-term curve to the trend-cycle data computed previously.
4. Calculate the cyclical component as ratios of the trend-cycle data to the fitted long-term trend curve. Refer to Step D.

We can summarize this process in symbolic formulas, with intuitive explanations of the economic-business logic underlying the computations. The following steps are in parallel with those enumerated previously:

Step A.
$$\frac{\text{Original sales}}{S} = \frac{O}{S} = \frac{T \times S \times C \times I}{S} = T \times C \times I = \begin{pmatrix}\text{Seasonally}\\\text{adjusted}\\\text{sales}\end{pmatrix} = \begin{pmatrix}\text{Trend-cycle-}\\\text{irregular sales}\\\text{components}\end{pmatrix} \tag{5.1}$$

where, S, the seasonal component, is calculated by the method illustrated in Tables 4.1 and 4.2 with additional statistical refinements by the X-11 Q computer program.

Step B.
$$\begin{pmatrix}\text{Seasonally}\\\text{adjusted}\\\text{sales}\end{pmatrix} \xrightarrow[\text{through a}]{} \begin{pmatrix}\text{Smoothing}\\\text{process}\end{pmatrix} = \begin{pmatrix}\text{Smoothed}\\\text{seasonally}\\\text{adjusted}\\\text{sales}\end{pmatrix} \tag{5.2}$$

or

$$(T \times C \times I) \begin{pmatrix}\text{Smoothing}\\\text{by 5-term}\\\text{Henderson}\\\text{curve process}\end{pmatrix} = T \times C = \begin{pmatrix}\text{Trend-}\\\text{cycle}\\\text{sales}\\\text{components}\end{pmatrix}$$

As a consequence of Step A and Step B results, we can further calculate:

Step C.
$$\frac{\text{Seasonally adjusted sales}}{\text{Trend-cycle sales}} = \frac{T \times C \times I}{T \times C} = I = \begin{pmatrix}\text{Irregular}\\\text{sales}\\\text{component}\end{pmatrix} \tag{5.3}$$

Step D.
$$\frac{\text{Trend-cycle sales}}{\text{Trend sales}} = \frac{T \times C}{T} = C = \begin{pmatrix}\text{Cyclical}\\\text{sales}\\\text{component}\end{pmatrix} \tag{5.4}$$

The "I" values for each period emerge as the ratios in Table 5.4. If the I's significantly change in size within the historical data, this is a signal to the forecaster that either he has not yet succeeded in removing all the seasonal influences or unusual business cycle considerations are present.

Figure 5.3 shows the original *quarterly* industrial wheel tractor unit sales from Table 5.1. Notice the strong seasonal pattern, with the second quarter typically 50 percent or more above the first quarter. Cyclical peaks are visible for 1966 and 1969 despite the strong seasonal pattern. Because of the many short-term oscillations and irregularities, we might expect a substantial irregular component in this series.

Figure 5.4 shows the changing seasonal factors calculated by the X-11 Q Program. Notice a slight upward trend in the first quarter seasonal factors which represent the bottom points of the cycles on the chart. These final seasonal factors, as reproduced in Table 5.2 for the first calendar quarter of data, increase from 0.739[3] in 1963 to 0.795 in 1972, expressed as ratios of the average quarter. Again referring to Figure 5.4, the second, third, and fourth quarters decline slightly over the identical time period. Thus the chart in Figure 5.4 clearly shows a recurring pattern within the year. This is the primary characteristic of seasonal patterns that enables us to statistically separate them from the other fluctuations in time-series data.

Seasonally adjusted quarterly data recorded in Table 5.5 appear graphically in Figure 5.5. Notice the appearance of the minor cyclical peak in the second quarter of 1964 and two major peaks in 1966 and 1969. The fourth quarter of 1972 is also a peak or will be an approach to a possibly higher later cyclical peak. The cyclical increases and decreases are fairly obvious in this chart of seasonally adjusted sales data, whereas Figure 5.3 with unadjusted data has so many seasonal fluctuations combined with cyclical fluctuations that visual analysis is difficult.

Table 5.2

Final Seasonal Factors for

Industrial Wheel Tractor Unit Retail Sales

2ND WH TR UNITS–FIEI DATA PAGE 8, SERIES INDTI

D10. FINAL SEASONAL FÅCTORS, 3X5 MOVING AVERAGE

YEAR	1ST QUAR	2ND QUAR	3RD QUAR	4TH QUAR	AV
1962				91.7	91.
1963	73.9	132.2	102.3	91.1	99.
1964	74.5	132.3	101.9	90.8	99.
1965	75.3	132.6	101.1	90.5	99.
1966	76.1	133.0	100.3	90.0	99.
1967	77.1	133.2	99.6	89.6	99.
1968	78.1	132.8	99.3	89.6	100.
1969	78.7	132.2	99.3	89.9	100.
1970	78.9	131.5	99.5	90.1	100.
1971	79.2	130.8	99.8	90.2	100.
1972	79.5	130.4	99.9	90.4	100

TABLE TOTAL 4089.3

Source: X-11 Q calculations from data in Table 5.1

Table 5.3

Final Trend-Cycle, 5-Term Henderson Curve

Industrial Wheel Tractors

2ND WH TR UNITS–FIEI DATA   PAGE 10, SERIES INDTRU

D12. FINAL TREND-CYCLE, 5-TERM HENDERSON CURVE

YEAR	1ST QUAR	2ND QUAR	3RD QUAR	4TH QUAR	TOTAL
1962					
1963	7615.	7626.	8016.	8355.	31612.
1964	8518.	8716.	8796.	8319.	34344.
1965	8019.	8412.	9207.	10094.	35732.
1966	10796.	10600.	9531.	8959.	39887.
1967	8829.	8720.	8916.	9288.	35752.
1968	9192.	9024.	9438.	9904.	37557.
1969	10460.	10846.	10504.	10003.	41812.
1970	10158.	10438.	10286.	10012.	40894.
1971	9734.	9792.	10381.	11186.	41094.
1972	11471.	11601.	12215.	12745.	48033.
AVG	9479.	9577.	9729.	9689.	

TABLE TOTAL 394429.   MEAN 9620.   STD. DEVIATION 1227.

Source: X-11 Q calculations based on Table 5.1

Table 5.4

Irregular Components: Ratios-to-Moving Average

Industrial Wheel Tractors

2ND WH TR UNITS—FIEI DATA PAGE 11, SERIES INDTRU

D13. FINAL IRREGULAR SERIES

YEAR	1ST QUAR	2ND QUAR	3RD QUAR	4TH QUAR	S.D.
1962				99.0	1.0
1963	102.3	97.1	100.9	101.6	2.1
1964	97.0	102.5	98.3	102.7	2.5
1965	95.1	100.6	101.5	97.1	3.0
1966	102.8	99.5	100.2	97.7	1.8
1967	105.6	98.8	98.4	102.8	3.3
1968	98.6	100.0	99.4	101.6	1.1
1969	95.4	102.3	100.3	97.1	3.0
1970	101.9	99.4	100.7	99.5	1.1
1971	100.5	99.2	99.6	100.7	0.6
1972	100.9	98.3	100.2	101.2	1.1
S.D.	3.2	1.6	1.0	2.0	

TABLE TOTAL 4098.5 MEAN 100.0 STD. DEVIATION 2.1

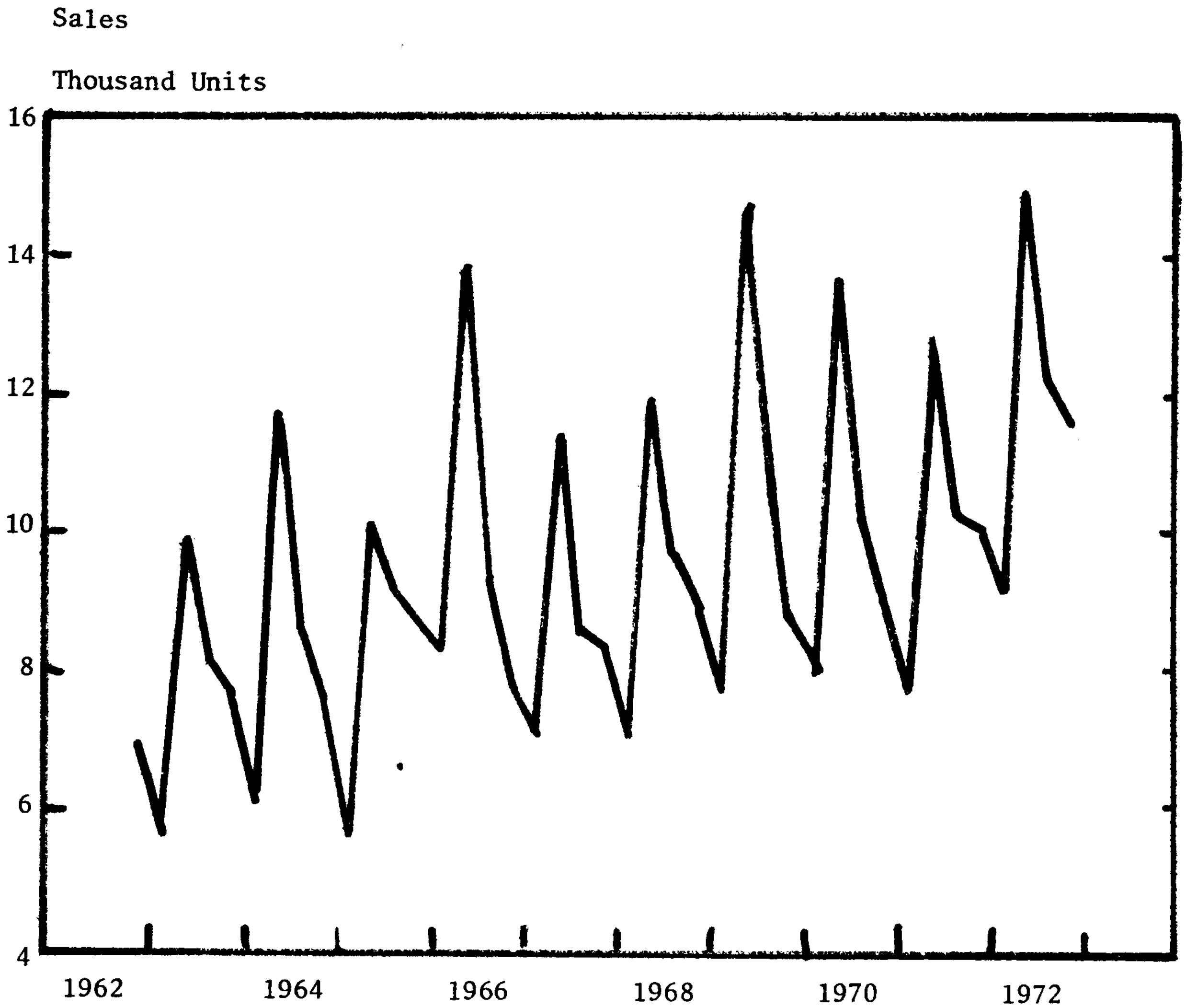
Source: X-11 Q calculations based on Table 5.1

Figure 5.3

Industrial Wheel Tractor

Industrial Unit Retail Sales, United States

Unadjusted Quarterly Data



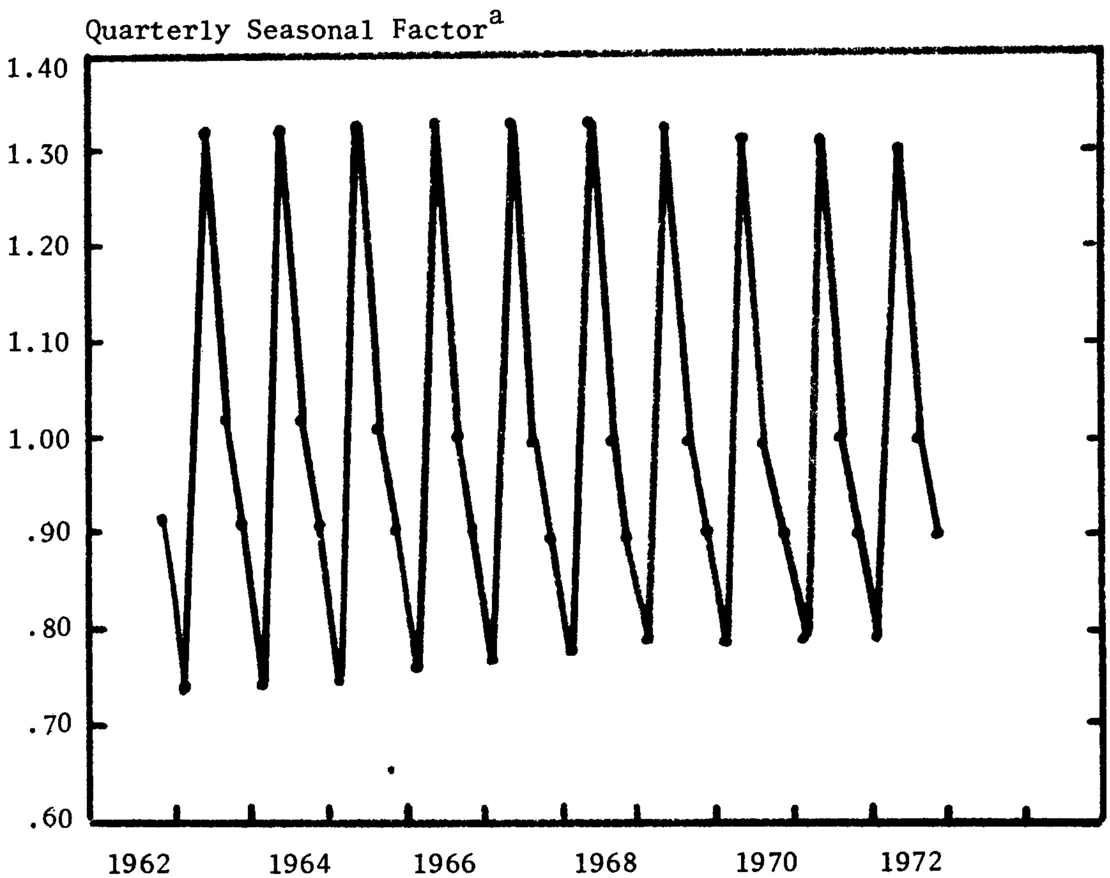
Source: Table 5.1

Figure 5.4

Industrial Wheel Tractor

Industry Unit Retail Sales, United States

Changing Seasonal Factors by Ratio -to-Moving-Average Method



[a]Average quarter = 1.00

Source: Table 5.2

Table 5.5

Final Seasonally Adjusted Sales

Industrial Wheel Tractors

2ND WH TR UNITS–FIEI DATA PAGE 9, SERIES INDTRU

D11. FINAL SEASONALLY ADJUSTED SERIES

YEAR	1ST QUAR	2ND QUAR	3RD QUAR	4TH QUAR	TOTAL
1962				7633.	7633.
1963	7791.	7407.	8092.	8488.	31778.
1964	8263.	8937.	8641.	8542.	34384.
1965	7624.	8462.	9344.	9804.	35235.
1966	11100.	10543.	9554.	8751.	39946.
1967	9326.	8618.	8777.	9552.	36273.
1968	9063.	9020.	9381.	10062.	37526.
1969	9980.	11096.	10541.	9710.	41328.
1970	10347.	10373.	10357.	9957.	41034.
1971	9786.	9718.	10344.	11263.	41112.
1972	11570.	11403.	12245.	12900.	48119.
AVG	9485.	9558.	9728.	9697.	

TABLE TOTAL 394367. MEAN 9619. STD. DEVIATION 1259.

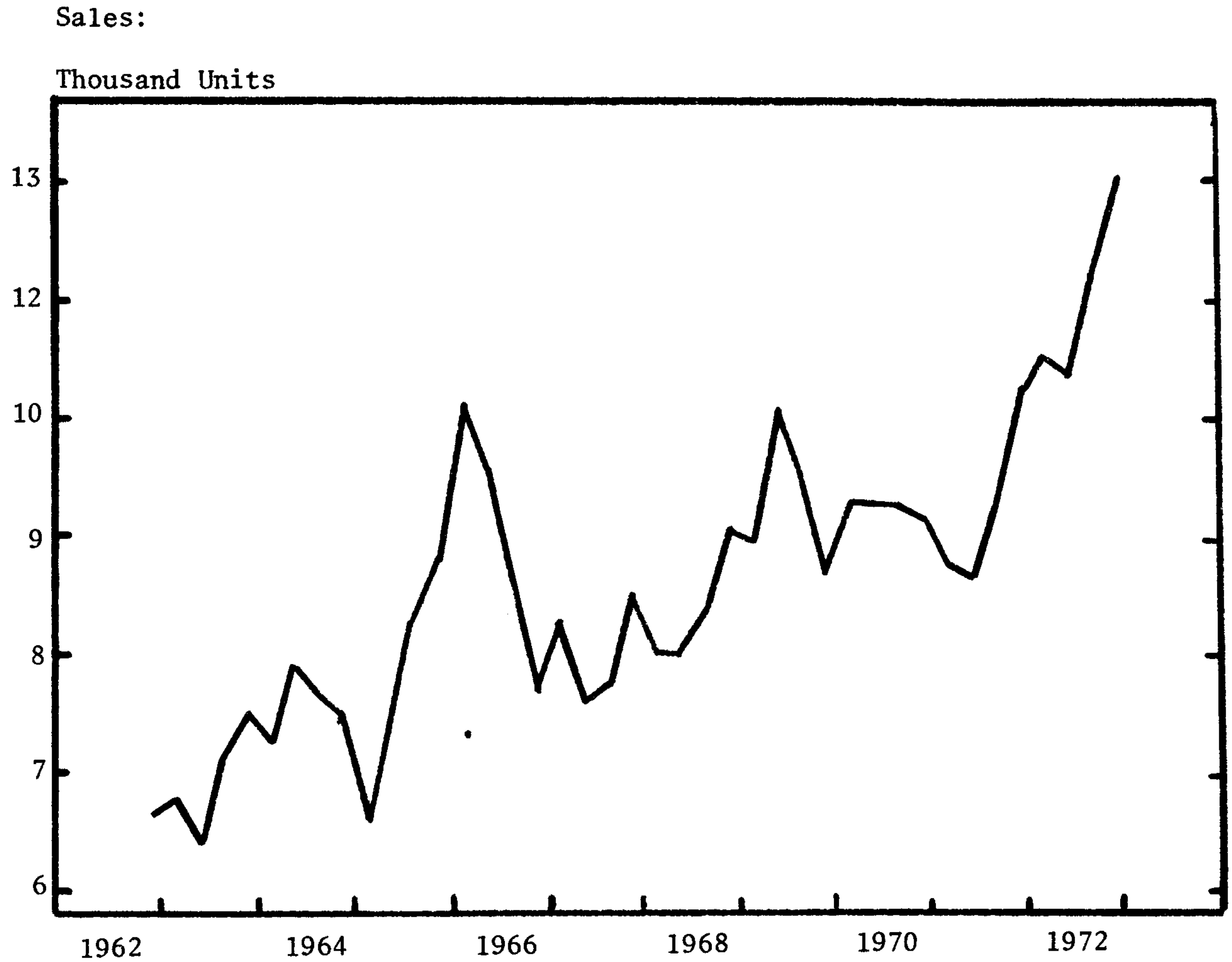
Source: X-11 Q calculations based on Table 5.1

Figure 5.5

Industrial Wheel Tractor

Industry Unit Retail Sales, United States

Seasonally Adjusted Quarterly Data



Source: Table 5.5

In Figure 5.5 a number of quarters reflect data which are oscillating in an opposite direction from the previous quarter. Since a one-quarter oscillation is not, in most instances, a business cycle peak, a procedure is needed to remove the effect of one-quarter oscillations. Such a result is shown for the trend-cycle data in Figure 5.6. The trend-cycle series is calculated by a smoothing process from the seasonally adjusted quarterly data, involving a five-term smoothing period with the center quarter having the highest weight and the first and last terms in the five-period time interval having the smallest weights. This is a polynomial smoothing process. Notice in Figure 5.6 that the major cyclical peaks still occur in the same quarters and appear in about the same fashion as in Figure 5.5. Likewise, the cyclical low points appear at the same times, but some of them are slightly modified. The only change in the timing of a peak between the two figures is for the second quarter peak in 1964 in the quarterly seasonally adjusted data, which now appears as a minor peak in the third quarter in the trend-cycle data. Hence, the difference between Figure 5.5 and Figure 5.6 is the removal of the major irregularities in the data using the 5-term Henderson Curve.

Irregular fluctuations are shown specifically in Figure 5.7 as ratios-to-trend-cycle. This irregular component is obtained by dividing the original seasonally adjusted sales series by the trend-cycle series.

The test for successful isolation of the irregular components is the presence of randomness, whereas a systematic pattern indicates failure. The irregular movements in Figure 5.7 visually appear to be reasonably random. (Illustrations of objective statistical tests of randomness are deferred to Chapter 7 and the Durbin-Watson test.)

A linear trend is fitted to the quarterly seasonally adjusted data and appears in Figure 5.8. This trend fits the shape of the data reasonably well.

Linear extrapolation for three years ahead appears in Figure 5.9. This projection is assessed as portraying a reasonable projection of the trend for the industrial wheel tractor industry.

For purposes of comparison, a second-degree polynomial trend is also fitted to these data and extrapolated through 1973-1975. These curved extrapolations are slightly higher than the linear trend projections but also are well within reason if the 1973 cyclical position is strongly positive. A choice between the two trends cannot be made from historical data alone; but since the two projections for three years are so similar, we prefer the second-degree trend due to its closer historical fit.

The pure cyclical component is illustrated in Figure 5.10, showing the ratios of the trend-cycle data to the second-degree polynomial trend fitted in Figure 5.9 (see Table 5.6). This pattern illustrates the typical description of business cycles in the U.S. economy, namely that they are irregular both in length and amplitude. Any kind of cycle forecasting using a mechanical repeating cycle, therefore, is virtually doomed to failure and should not be used unless there is evidence of a mechanical oscillating type of cycle in data which can be clearly identified and justified in economic causation. Possible examples of such mechanical oscillating cycles are the long-term (ten to twelve years) beef cattle supply cycle and the much shorter hog-supply cycle. In these cases, the occurrence of a cyclical peak by definition creates the conditions for a later decline, and the length of the cycle is a direct biological function of the feeding and reproduction rate in cattle and hogs, as well as the usual time required for farmers to adjust their feeding practices in response to price changes.

5.3 Seasonal vs. Cyclical Patterns

Business sales series may reflect odd, and sometimes extreme, combinations of seasonal and cyclical influences. For example:

1. Safeway original and seasonally adjusted sales in Part A of Figure 5.11 show moderate seasonal fluctuations around trend and no visible business cycle. The seasonal fluctuations exceed the cyclical fluctuations.
2. In contrast, Process Control original sales in Part B of Figure 5.11 show small seasonal fluctuations, and the seasonally adjusted data depict substantial business cycle fluctuations in 1966 to 1972. Here the cyclical fluctuations exceed the seasonal fluctuations, just the opposite of Safeway's case.
3. Finally, industrial wheel tractor unadjusted sales in Part C of Figure 5.11 show wide seasonal fluctuations that far exceed the cyclical fluctuations, and at the same time the seasonally adjusted cyclical fluctuations are substantial, approximately as wide as those for Process Control's sales.

These three examples are provided to illustrate that forecasting a specific product group may be complicated by combinations of extreme seasonal and/or cyclical conditions.

5.4 Summarizing the Multiplicative Model of Time-Series Analysis

Table 5.7 shows in symbolic and numerical form an example of aggregate results for multiplicative time-series analysis (Chapters 3, 4, and 5) using specific data for industrial wheel tractors, fourth quarter 1972.

To recap:

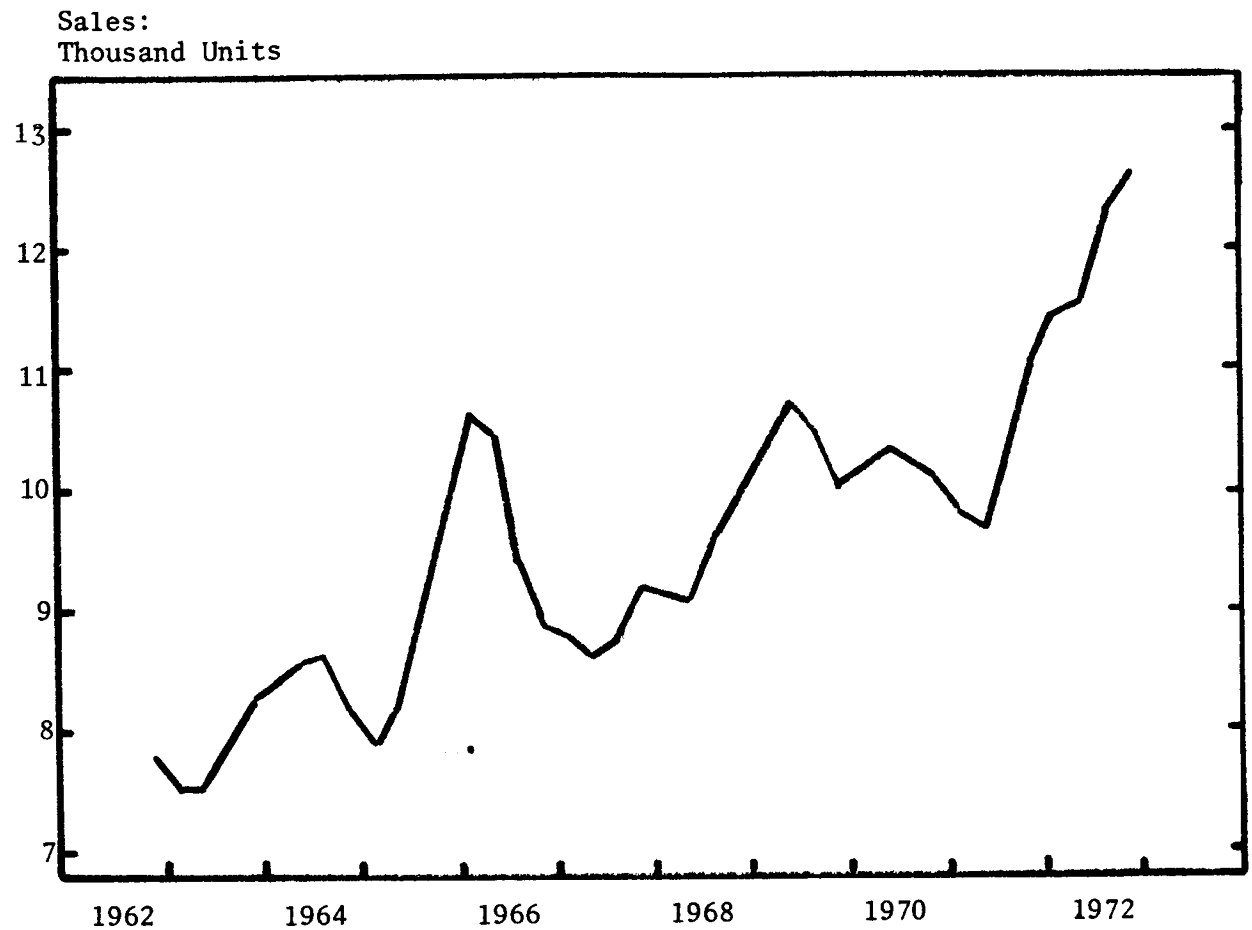
○ Original = O = 11,655 tractors.
○ Seasonal = S = 0.904, which is the ratio of the average second quarter near the end of the time series to an average quarter or ¼ of a year.
○ Trend = T = 12,745 tractors, which comes from fitting a second-degree polynomial by the method of least-squares to the quarterly data.
○ Irregular = I = 1.012, expressed as a ratio of seasonally adjusted sales to the trend cycle.
○ Cycle = C = 1,103, expressed as a ratio of the trend cycle to the trend.

The last ratio, the cycle ratio, says that 1972 fourth quarter sales, seasonally adjusted and smoothed, are 10.3 percent above the long-term trend.

5.5 Using Cyclical and Irregular Components in Forecasting

Put bluntly, traditional time-series analysis runs out of

Figure 5.6
Industrial Wheel Tractor
Industrial Unit Retail Sales, United States
Trend-Cycle Components by 5-term Henderson Curve
(Smoother version of Figure 7.5)
Quarterly Data



Source: Table 5.3

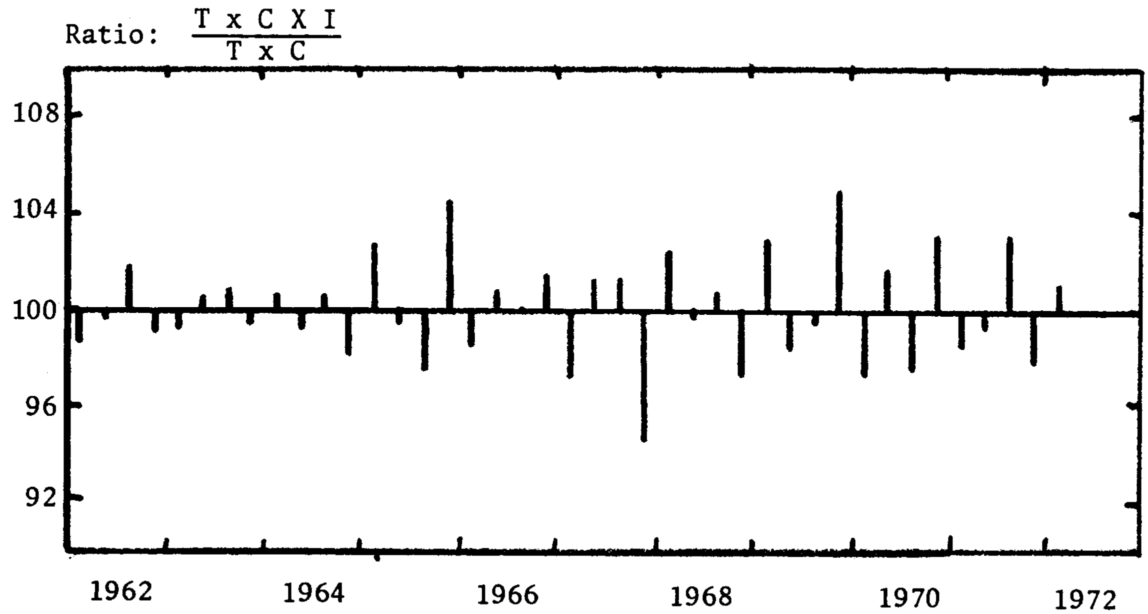
Figure 5.7

Industry Wheel Tractor

Industry Unit Retail Sales, United States

Irregular Component: Ratios of Quarterly Seasonally

Adjusted Sales to Trend-Cycle Sales.



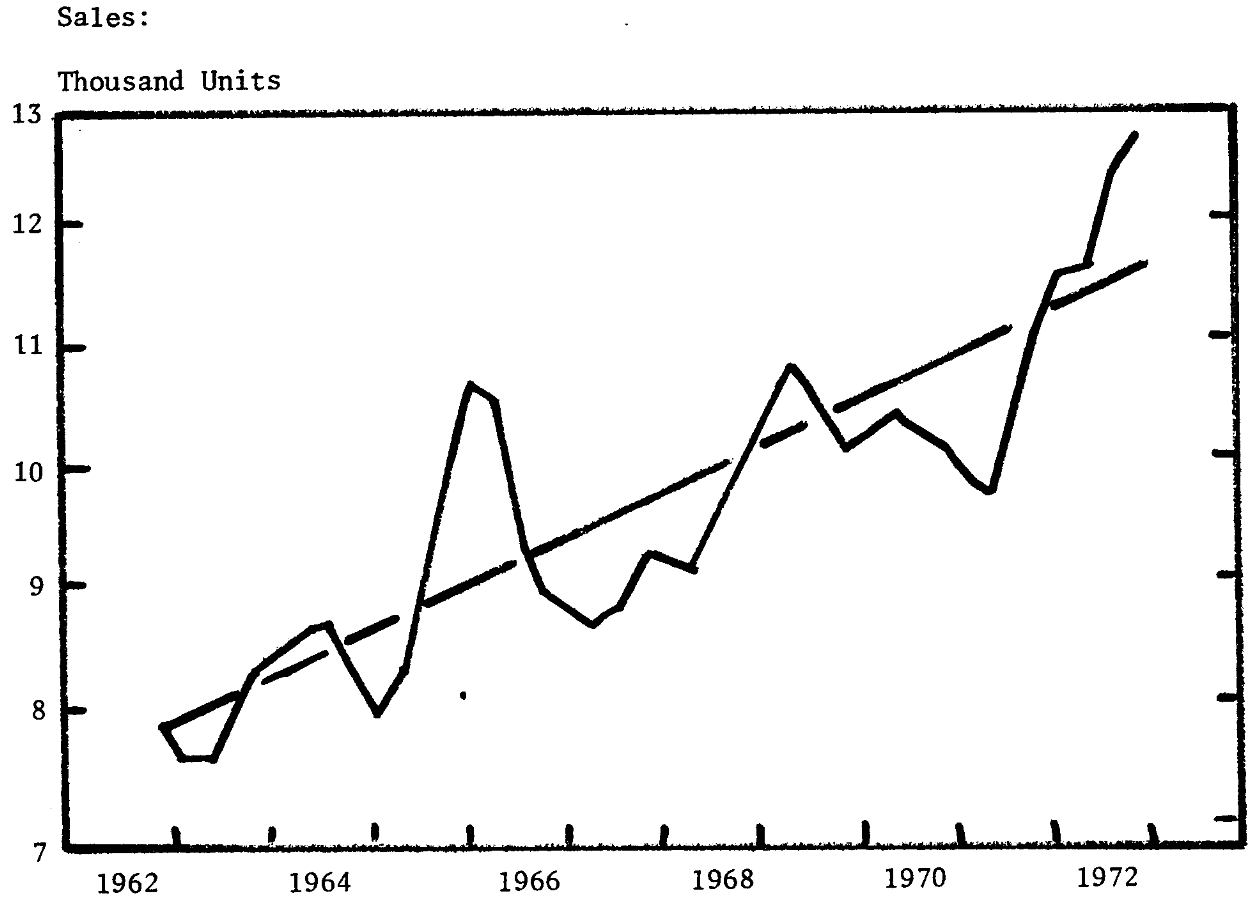
Source: Table 5.4

Figure 5.8

Industrial Wheel Tractor

Industry Unit Retail Sales, United States

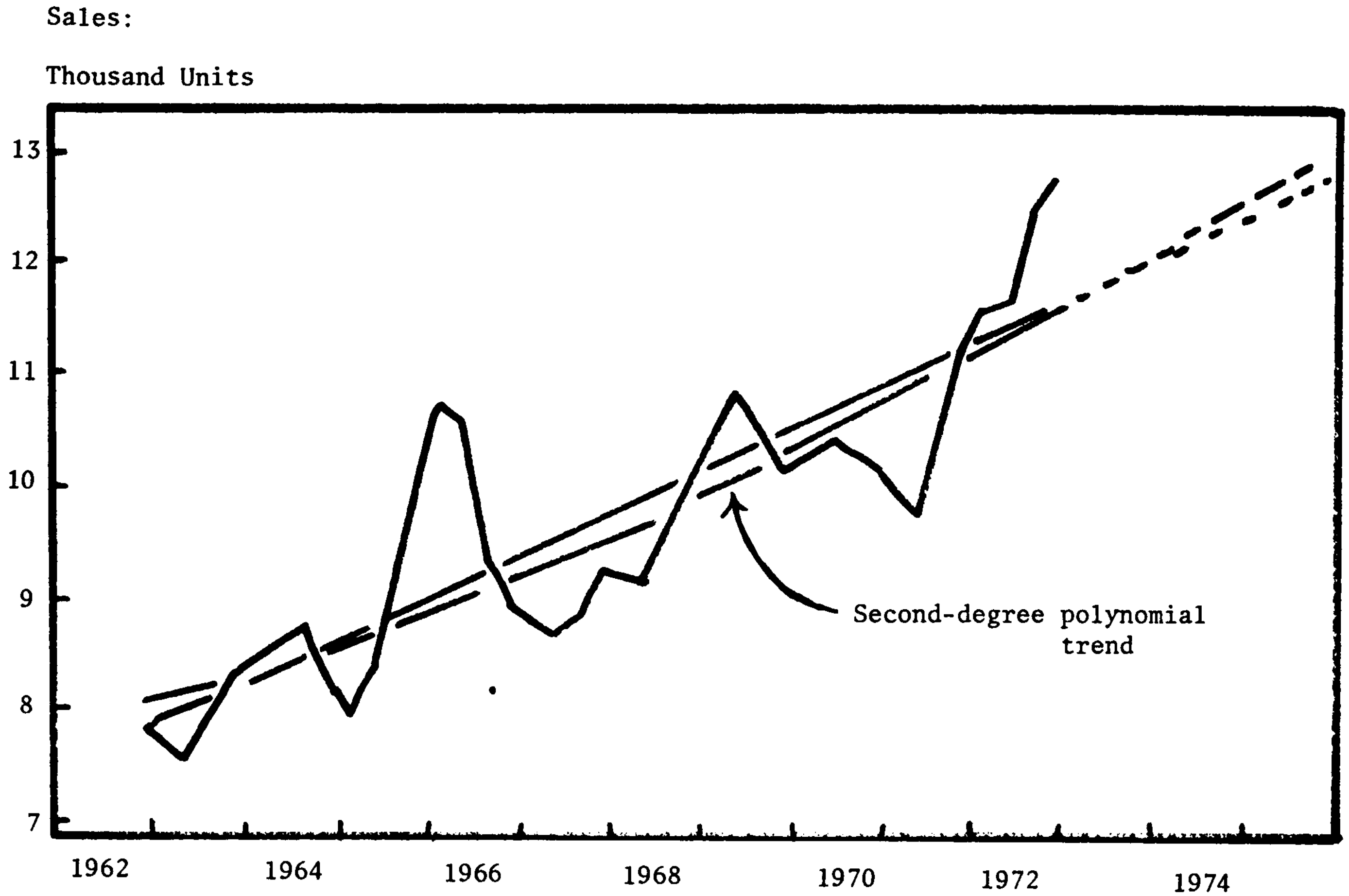
Linear Trend Through Seasonally Adjusted Quarterly Trend-Cycle Sales



Source: Table 5.3

Figure 5.9

Industrial Wheel Tractor
Industry Unit Retail Sales, United States
Linear Trend, and Second-Degree Polynomial Trend,
Extrapolated to 1975
Seasonally Adjusted Quarterly Sales



Source: Table 5.6

Figure 5.10

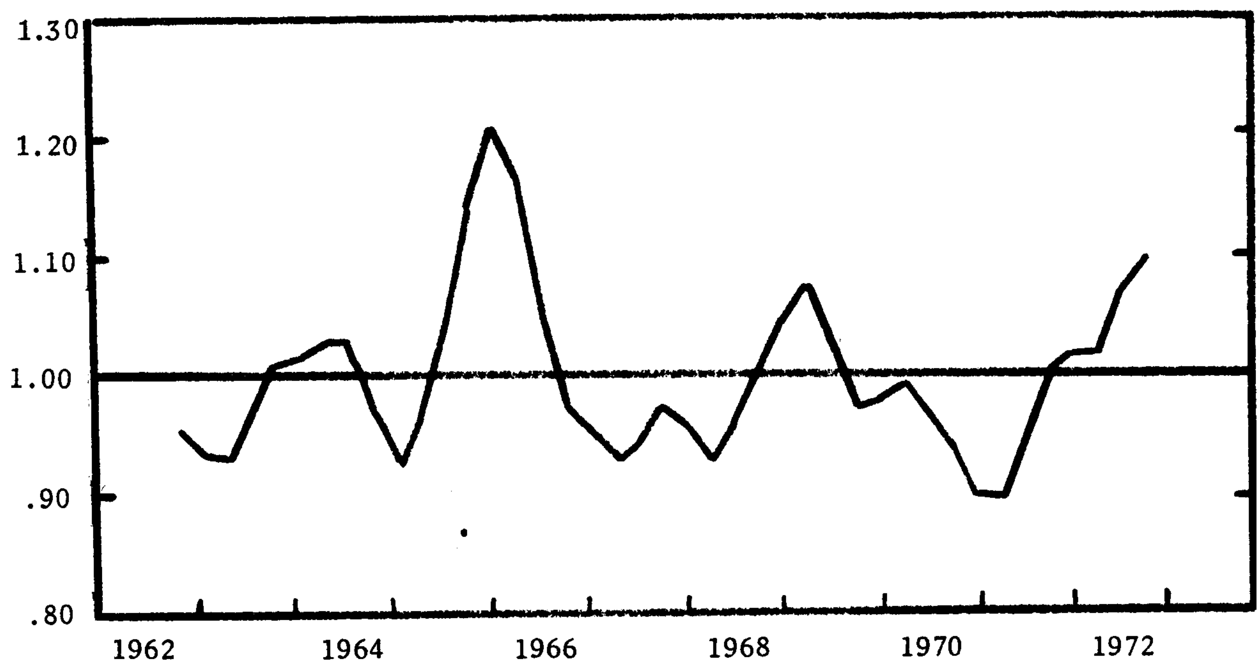
Industrial Wheel Tractor

Industry Unit Retail Sales, United States

Cyclical Component

Quarterly Data

Ratio-to-trend = $\frac{T \times C}{T}$



Source: Table 5.6

Table 5.6

Calculating the Cyclical Component for

Industrial Wheel Tractor Unit Retail Sales

(1) Year and Quarter	(2) Trend-Cycle Sales (Table D12 of X 11-Q Program)	(3) Trend (Calculated as Least-Squares Second Degree Polynomial)	(4) Cycle $\frac{(2)}{(3)}$
	Units	Units	Ratio of Trend-Cycle to Trend
1962-4	7,713	8,055	0.958
1963-1	7,615	8,115	0.938
1963-2	7,626	8,176	0.933
1963-3	8,016	8,238	0.973
1963-4	8,355	8.302	1.006
1964-1	8,518	8,367	1.018
1964-2	8,716	8,434	1.033
1964-3	8,790	8,502	1.034
1964-4	8,319	8,572	0.970
1965-1	8,019	8,643	0.928
1965-2	8,412	8,715	0.965
1965-3	0,207	8,789	1.048
1965-4	10,094	8,865	1.139
1966-1	10,796	8,942	1.207
1966-2	10,600	9,020	1.175
1966-3	9,531	9,100	1.047
1966-4	8,959	9,181	0.976
1967-1	8,829	9,263	0.953
1967-2	8,720	9,347	0.933
1967-3	8,916	9,433	0.945
1967-4	9,288	9,520	0.976

.Table 5.6 , Page 2

(1)	(2)	(3)	(4)
1968-1	9,192	9,608	0.957
1968-2	9,024	9,698	0.931
1968-3	9,438	9,789	0.964
1968-4	9,904	9,976	1.002
1969-1	10,460	10,071	1.049
1969-2	10,846	10,168	1.077
1969-3	10,504	10,266	1.033
1969-4	10,003	10,366	0.974
1970-1	10,158	10,366	0.980
1970-2	10,438	10,468	0.997
1970-3	10,286	10,570	0.973
1970-4	10,012	10,674	0.938
1971-1	9,734	10,780	0.903
1971-2	9,792	10,887	0.899
1971-3	10,381	10,995	0.944
1971-4	11,186	11,105	1.007
1972-1	11,471	11,216	1.023
1972-2	11,601	11,329	1.024
1972-3	12,215	11,443	1.067
1972-4	12,745	11,559	1.103

Source: Farm and Industrial Equipment Institute, and calculations from X11Q program.

Figure 5.11

Contrasts in Seasonal Versus Cyclical Fluctuations

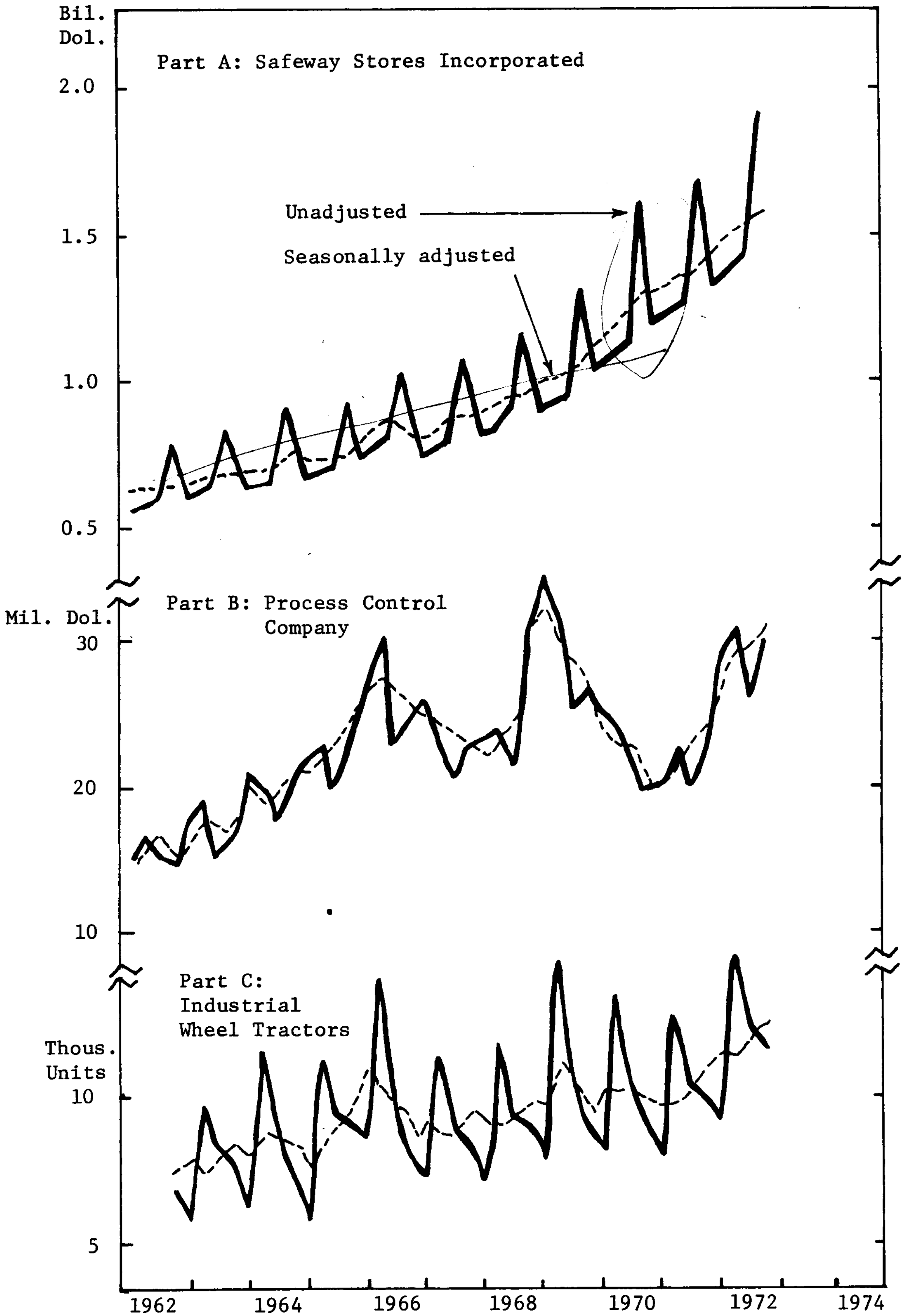


Table 5.7

Analysis of 1972 Fourth Quarter
Industrial Wheel Tractor Unit Sales
Into Four Time Series Components

Line	Time Series Component	Symbol for Component	Symbolic Derivation	Value of Component	Source
1	Actual or Original	$0 = T \times S \times C \times I$	Original data	11,655 tractors	Table 7.1
2	Seasonal	S	$\frac{T \times S \times C \times I}{T \times C \times I}$	0.904 (changing seasonal factors)	Table 7.2
3	Seasonally Adjusted Sales	$T \times C \times I$	$\frac{T \times S \times C \times I}{S}$ or $\frac{\text{Line 1}}{\text{Line 2}}$	12,900 tractors	Table 7.5
4	Trend-Cycle	$T \times C$	Smoothing of $T \times C \times I$	12,745 tractors	Table 7.3
5	Irregular	I	$\frac{T \times C \times I}{T \times C}$	1.012 (irregular ratio)	Table 7.4
6	Trend	T	Least-squares fitting of second degree polynomial	11,559	Table 7.6
7	Cycle	C	$\frac{T \times C}{T}$ or $\frac{\text{Line 4}}{\text{Line 6}}$	1.103	Table 7.6

8 Complete Expression: $0 = T \times S \times C \times I$

11,655[a] tractors = 11,559 tractors x 0.904 x 1.103 x 1.012

a/ Product does not exactly equal 11,655 tractors due to rounding of the component figures.

"steam" at the point of determining irregular and cyclical fluctuations in ways that are useful for sales forecasting.

The following brief statements summarize the approximate state of the art for the sales forecaster:

1. Time-series analysis is of little help in forecasting business cycles. The sales forecaster must resort to causal economic methods, i.e., essentially to the route of independent explanatory variables in multiple regression techniques (Chapter 8). Another route is applied econometrics, and when necessary for a large industry, a full-scale econometric model for either a sector of the economy or for the whole economy (see Chapter 12). Examples of profitable construction for such models currently exist in many large corporations, and these models have in some cases been highly successful in improving sales forecasts. Further routes include simulation models (Chapter 10) and input/output models (Chapter 11).

2. Small irregular fluctuations are never forecast, and the forecaster must assume a zero average for this component.

3. Major irregular events, which are sometimes classified as innovative cyclical influences, must be anticipated in a good sales forecast, but the methods again come from causal economics, multiple regression, and econometrics, rather than from any time-series framework.

In view of practical experience, then, there is no wholly satisfactory statistical method for measuring the irregular fluctuations and the cyclical peaks and troughs in time-series analysis. The best approach to this measurement problem has been by indirect methods which presume the independence of the trend, seasonal, cyclical, and irregular components in a time series. This presumption generally is approximately correct for the seasonal component, but both cyclical and irregular components are highly variable with trends also sometimes changing abruptly.

Footnotes

1. A "3x5" moving average in this case is the result of performing a three-quarter moving average successively five times on the specific seasonal factors to obtain a final set of changing seasonal factors; i.e., initially take a moving average of the original specific seasonal factors, then a second moving average of these results, with this procedure being followed until a fifth moving average of successively refined seasonal factors is taken to give the final results in Table 5.2.

2. A "5-term Henderson Curve" is a smoothing process in which weighting factors are polynomially distributed. This technique is sometimes referred to as "polynomial smoothing."

3. We prefer the use of decimals rather than percents as reported in tables of the X-11 Q Program because we use the decimal form of seasonal factors for computation in the multiplicative time-series analysis model.

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